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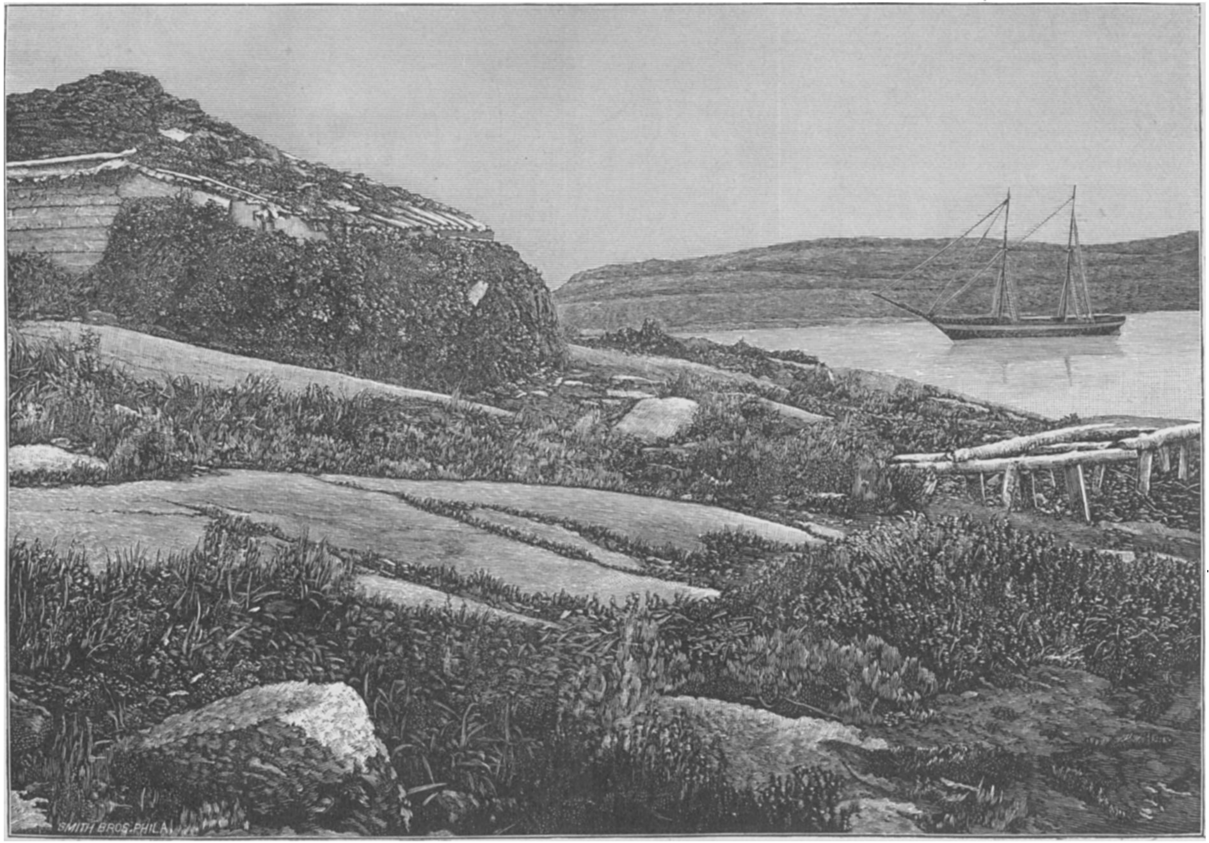
PLATE III.


SMITH BROS. PHILA.

Glacial Planing in Labrador.

THE

AMERICAN NATURALIST.

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THE BLIND CAVE FISHES AND THEIR ALLIES.

BY S. A. FORBES.

AN unusual interest attaches to everything relating to the blind fishes of the caves, partly because of their peculiar deprivation and the compensation for it afforded by the development of special sensory structures more useful to them in their subterranean situation than eyes would be, and partly because the origin of their peculiarities has proved an inviting subject of speculation and discussion with reference to the doctrine of natural selection. In the careful papers of Mr. F. W. Putnam,[1] especially, we find accurate descriptions of the genera and species, and a clear statement of opposing views respecting the derivation of these little fishes.

A strict evolutionist passes, perhaps too easily, from the idea of the unbroken, rayless night in which the blind fishes live and seem to have lived for ages, to that of their atrophied eyes and highly developed epidermal organs of sense—connecting these at once as cause and effect on the strength of his general theory. In papers written, one nine and the other seven years ago, Mr. Putnam presented, partly in criticism of previously published explanations of Mr. Cope,[2] facts and considerations which seemed to him to break the force of the argument based by evolutionists upon the peculiar adaptation of the blind fishes to their surroundings, and even to compel the conclusion that the darkness of their situation did not bring about the atrophy of their eyes, the development of their special organs of sense, or the bleaching of their skins.

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[1] AMERICAN NATURALIST, January, 1872. Annual Report of the Peabody Academy of Science for 1871. Proceedings of the Boston Society of Natural History, Vol. XVII, 1874, pp. 222–225.

[2] Ann. Mag. Nat. Hist., Nov., 1871.

The discussion seems not to have been carried further; and I now revive the subject because the study of a new species closely allied to the blind fishes, which has recently been discovered in Illinois, enables me to contribute a few facts which throw additional light upon it.

In the papers cited, it is argued, in brief, that the conclusions as to adaptation based upon the absence of functional eyes and the extraordinary development of tactile organs in Amblyopsis and Typhlichthys are negatived by the fact that in Chologaster, an equally subterranean genus, tactile organs are wanting, and eyes are fully developed. If genera without eyes, and another genus with them, are found living under the same conditions, the inference is obvious that the conditions cannot have caused this difference.

The possible rejoinder that Chologaster may still retain its eyes because it has had a shorter subterranean history, and has not yet become so thoroughly adapted to cave life as its predecessors, is forestalled by the argument that we have no right to assume that Chologaster is a later inhabitant of underground retreats than the blind fishes, until at least one specimen of the former has been found in the outer waters in the vicinity of the caves. The same reasoning is applied to the difference of color—Amblyopsis being colorless and Chologaster brown.

On page 232 of the NATURALIST for March, 1881, I briefly described a single specimen of Chologaster obtained by Mr. F. S. Earle from a spring in Southern Illinois; but did not undertake to decide, from a single example, whether it belonged to a distinct species or not. Seven additional specimens obtained by the same gentleman from the same place, agree so closely with the one previously found that it is evident that all belong to one species, and I have no longer any doubt that this is distinct from the two previously described.[1]

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[1] *Chologaster papilliferus*, n. s. The head is broad and flat, contained three and a-half times in the body (without caudal), widest posteriorly and broadly rounded in front. Its width between the eyes is half its length. The eye is contained about six times in the length of the head, and is placed above and behind the tip of the maxillaries. The greatest depth of the body is contained five times in its length to caudal. The pectoral fins reach only half way to the anal; and the caudal is broadly

The most important and interesting peculiarity of this species indicates a more advanced stage of adaptation to a subterranean life than that of its congeners. On all the surfaces of the head appear short rows of peculiar tubercles, relatively wider than the papillæ of Amblyopsis, but also apparently shorter. They are much the largest about the anterior nostril and on the lower jaw, and are larger on the side of the head than on its upper surface. While the papillæ of Amblyopsis are set on ridges of the skin, those of this Chologaster are somewhat sunken within it, and often placed in grooves; and it is not until they are freed from the adjacent epidermis by dissection, that their full height is seen. When thus exposed they closely resemble the papillæ of Amblyopsis in form and size, and are similarly cupped at the tip. Aver-

rounded and almost truncate. The color is brown above, paler below, with three narrow longitudinal stripes, the upper and lower black, the middle one pale with narrow black edging above and below. With a glass the ground color is seen to be everywhere minutely mottled black and white. The fins are all nearly or quite concolorous, except the caudal, which is minutely marked with rows of white specks on a dusky ground. These specks indicate the articulations of the fin rays. There is usually a dusky vertical bar at base of tail. The dorsal and anal fins are thick and fleshy, their height about equal to their length, the former with six and the latter with five rays.

On all surfaces of the head, peculiar tubercles or papillæ occur in short rows, much the largest on the lower jaw and about the anterior nostril, where they are sunken in grooves of the skin. They are also larger on the side of the head than above. An irregular double row surrounds the anterior nostril, except externally, and behind this appear four short, transverse rows on each side, the last of these being a little behind and within the eye. Then follow about eight short, irregularly placed, oblique and transverse rows, accompanied posteriorly by a longitudinal row. On each side of the middle of the back part of the head is a short longitudinal row, each with a small patch not far from its tip. At the upper end of the gill-slit is a conical tubercle with an apical perforation; and traces of a series of vertical rows of tubercles appear on the anterior part of the side of the body. The side of the head bears many short vertical rows, with some longitudinal and oblique rows also. On the under side of the lower jaw, a double or triple row of large papillæ is set in a groove just within the jaw, and a small, triangular, sunken patch is found a little within the anterior end of this row. Another longer row of smaller papillæ runs parallel to the former, between it and the hyoid arch. Average specimens measure 37mm. in total length.

This species presents the internal characters of the genus, as defined by Mr. Putnam in his "Synopsis of the family Heteropygii," published in the Annual Report of the Peabody Academy of Science for the year 1871. The description of the genus should be amended, however, by the omission of the statement concerning papillary ridges and an opercular papilla.

Taken from a spring at the base of a limestone bluff, in Union county, in Southern Illinois.

age examples from the largest sub-maxillary row measured .01 in height by half that width. I found no projecting filament, however, in any of the cups, such as is described and figured by Professor Wyman in the papers of Mr. Putnam already cited. The interior structure of the papillæ also differs greatly from that of Amblyopsis, as the latter is represented by Professor Wyman. In Amblyopsis, according to that eminent anatomist, each papilla is supplied with a nerve fiber which terminates in a short, flexible filament springing from the middle of the concavity in the tip of the papilla. In the Chologaster each papilla is likewise penetrated by a nerve fiber, which is very easily traced, even without the help of reägents, because of the black pigment in the neurilemma, but this nerve passes to an epidermal "end organ" precisely similar in structure to those minute bodies found abundantly embedded in the skin of the head of young fishes, and belonging to the same general class as those sensory structures which occupy the lateral line.

This "end organ," or "nerve button," which fills the interior of the distal third or half of the papilla, is a nearly globular mass of cells, partly various modifications of the columnar, and partly spindle-shaped or spherical, each of the latter with a filamentous prolongation at one or both ends. The nerve fiber of the papilla passes, without division, to the inner end of the cell-cluster, where its fibrils appear to continue into the filamentous processes of the cells. Having no fresh material for the osmic acid treatment, I could not positively demonstrate the terminations of the fibrils. These are evidently simple examples of that class of structures to which a supposed "sixth sense" of fishes and amphibians has been assigned, and by which these animals are believed to appreciate motions of the water and wave lengths longer than those of sound.

The importance of well developed structures of this character to fishes without the use of the sense of sight, is very manifest. The close general resemblance between these organs and those described for the blind fishes, taken in connection with their similar situation, arrangement and apparent use, is probably sufficient evidence that the two kinds are homologous.[1]

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[1] Is it not possible that the specimens of Amblyopsis studied by Professor Wyman were not perfectly preserved, and had lost more or less of their superficial epithelium, and with this the "nerve buttons" from the tips of their papillæ? Some color

Recurring now to the argument of Mr. Putnam, we note that the discovery of a species of Chologaster which frequents external waters of an immediately subterranean origin, supplies all needed proof that the genus either has a shorter subterranean history than Amblyopsis, or, at any rate, has remained less closely confined to subterranean situations; and that in either case the occurrence of eyes, partial absence of sensory papillæ and persistence of color, are thus accounted for consistently with the doctrine of "descent with modification."

The extraordinary development, in only a part of the genus, of a special sensory apparatus peculiarly useful to a fish unable, for any cause, to see, points the same way, and gives evidence of a *progressing* adaptation of these fishes to their unusual abode.

The intermediate relation of the sensory tubercles of Chologaster to the much smaller ones of young fishes and the permanent papillæ of Amblyopsis, points out the evident origin of the last through the permanency and higher evolution of structures commonly evanescent in the young.

is given to this surmise by the statement, in the papers cited, that his fishes were provided with only a single layer of delicate epithelium; whereas most fishes, and especially the naked and nearly naked kinds, are usually covered with an epidermis several layers deep, and by the further fact that the papillæ of Chologaster would accurately resemble those figured in Mr. Putnam's paper (except for the filament), if the former were denuded, as supposed.

After the above was sent to the printers, Mr. Putnam kindly sent me an alcoholic specimen of Amblyopsis with the epidermis intact over considerable areas of the head. An examination of the sensory structures of these regions at once showed the correctness of my surmise, that they are in Amblyopsis, as in the new Chologaster, to be definitely classed with the so-called "organs of the sixth sense," and are simply more highly developed examples of the structures found in the heads of young fishes. Each papilla bears at its tip a cluster of sensory cells in all respects similar to those above described; and I have little doubt that the figures of Prof. Wyman were made from denuded papillæ which had accidentally lost their sensory cells. The "filaments" seen by him on two or three of the papillæ were probably remnants of the cell clusters. The epidermis of the head is not composed of a single layer of delicate cells, as described by him, but of at least three layers—a deeper, columnar one, a median layer of large spherical or oval cells, with granular contents, and a superficial layer of thin, flat cells. The epidermis is, in fact, so thick that it almost or quite conceals the folds of the true skin upon which the papillæ are borne.

A fuller account of these structures will be given in another article.